WHAT IS CLAIMED IS:

1. An adaptive optics imaging system with object acquisition capability comprising:

a primary imaging subsystem comprising:

a telescope having an optical axis;

a variable phase device located on the optical axis; and

a wavefront sensor located on the optical axis downstream of the variable phase device;

an acquisition imaging subsystem located in a fixed position relative to the primary imaging subsystem, the acquisition imaging subsystem comprising:

an optical imager having an optical axis;

a reference object located in an object plane of the optical imager; and

an acquisition detector located at an image plane of the optical imager;

a beamsplitter that splits the telescope's optical axis upstream of the variable phase device and also splits the optical imager's optical axis, wherein the wavefront sensor is located at an image plane of the optical imager, the acquisition detector is located at an image plane of the telescope, and a field of view of the acquisition detector is larger than a field of view of the wavefront sensor;

a first controller that controls the variable phase device to align the reference object and the wavefront sensor; and

a second controller that controls a beam steering mechanism for the telescope, to align a target object for the telescope and the reference object.

2. The adaptive optics imaging system of claim 1 wherein the variable phase device comprises a deformable mirror.

3. The adaptive optics imaging system of claim 1 wherein the first controller is coupled between the wavefront sensor and the variable phase device and controls the variable phase device responsive to signals from the wavefront sensor.

4. The adaptive optics imaging system of claim 1 wherein the wavefront sensor uses a pair of defocused pupil images.

5. The adaptive optics imaging system of claim 1 wherein the reference object comprises an end of an optical fiber.

6. The adaptive optics imaging system of claim 1 wherein the reference object has an adjustable amplitude.

7. The adaptive optics imaging system of claim 1 wherein the primary imaging subsystem is designed for operation in a first wavelength band, and the acquistion imaging subsystem is designed for operation in a second wavelength band, and the first and second wavelength bands do not overlap.

8. The adaptive optics imaging system of claim 7 wherein the reference object comprises an end of an optical fiber, and light from both wavelength bands exit the end of the optical fiber.

9. The adaptive optics imaging system of claim 7 wherein the target object comprises:

a primary object in the first wavelength band; and

a beacon in the second wavelength band, wherein a position of the beacon relative to the primary object is known.

10. The adaptive optics imaging system of claim 7 wherein the beamsplitter has a first splitting ratio at the first wavelength band and a second splitting ratio at the second wavelength band, and the second splitting ratio is not equal to the first splitting ratio.

11. The adaptive optics imaging system of claim 1 wherein the primary imaging subsystem and the acquistion imaging subsystem are both designed for operation at a same wavelength band.

12. The adaptive optics imaging system of claim 1 wherein the acquisition detector comprises an imaging array.

13. The adaptive optics imaging system of claim 1 wherein the second controller is coupled between the acquisition detector and the beam steering mechanism and controls the beam steering mechanism responsive to signals from the acquisition detector.

14. The adaptive optics imaging system of claim 13 wherein the acquisition detector comprises an imaging array.

15. The adaptive optics imaging system of claim 1 wherein the beam steering mechanism comprises either a steering mirror or a mechanical gimbal.

16. The adaptive optics imaging system of claim 1 wherein an angle between the beamsplitter and either optical axis is not forty-five degrees.

17. The adaptive optics imaging system of claim 1 wherein the telescope has an intermediate image plane located upstream of the beamsplitter and the reference object is a virtual conjugate of the intermediate image plane.

18. A method for acquiring a target object using an adaptive optics imaging system comprising a telescope having an optical axis, and a variable phase device and a wavefront sensor located on the optical axis, the method comprising:

providing a reference object;

imaging the reference object onto an acquisition detector located at an image plane of an optical imager;

splitting the optical axis of the telescope upstream of the variable phase device and splitting an optical axis of the optical imager, wherein the wavefront sensor is located at an image plane of the optical imager and the acquisition detector is

located at an image plane of the telescope, and a field of view of the acquisition detector is larger than a field of view of the wavefront sensor;

controlling the variable phase device to align the reference object and the wavefront sensor; and

controlling a beam steering mechanism located in the telescope's optical axis upstream of the beamsplitter, to align a target object for the telescope and the reference object.

19. The method of claim 18 wherein controlling the variable phase device is further responsive to signals from the wavefront sensor.

20. The method of claim 18 wherein the primary imaging subsystem is designed for operation in a first wavelength band, and the acquistion imaging subsystem is designed for operation in a second wavelength band, and the first and second wavelength bands do not overlap.

21. The method of claim 20 wherein providng the reference object comprises providing a reference object in both wavelength bands.

22. The method of claim claim 18 wherein controlling the beam steering mechanism is further responsive to signals from the acquisition detector.

23. The method of claim 22 wherein the acquisition detector comprises an imaging array.

24. A method for acquiring a target object using an adaptive optics imaging system comprising a wavefront sensor, the method comprising:

aligning the wavefront sensor to a reference object;

aligning the target object to the reference object; and

maintaining alignment of the target object with the wavefront sensor.

25. The method of claim 24 wherein the adaptive optics imaging system further comprises a variable phase element and wherein:

the step of aligning the wavefront sensor to a reference object comprises adjusting the variable phase element to align the wavefront sensor to the reference object; and

the step of maintaining alignment of the target object with the wavefront sensor comprises adjusting the variable phase element to maintain alignment of the target object with the wavefront sensor.

26. A free-space optical data transmission system comprising:

first and second imaging systems spaced from and aimed at each other, wherein at least one of the imaging systems comprises the adaptive optics imaging system of claim 1; and

a light transmitter operably coupled to the first imaging system for providing data-encoded light to the first imaging system, that directs the data-encoded light to the second imaging system.

27. The free-space optical data transmission system of claim 26 wherein each imaging system comprises the adaptive optics imaging system of claim 1.

28. The free-space optical data transmission system of claim 26 further comprising:

a second light transmitter operably coupled to the second imaging system for providing data-encoded light to the second imaging system, that directs the data-encoded light to the first imaging system.

29. The free-space optical data transmission system of claim 26 wherein the second imaging system comprises the adaptive optics imaging system of claim 1, and the target object comprises the data-encoded light.

30. The free-space optical data transmission system of claim 29 wherein the primary imaging subsystem is designed for operation in a first wavelength band, the data-encoded light lies in the first wavelength band, the acquistion imaging subsystem is designed for operation in a second wavelength band, and the first and second wavelength bands do not overlap.

31. The free-space optical data transmission system of claim 30 wherein the target object further comprises:

a beacon in the second wavelength band, wherein a position of the beacon relative to the data-encoded light is known.

32. The free-space optical data transmission system of claim 26 wherein the target object comprises:

a primary object; and

a beacon, wherein a position of the beacon relative to the primary object is known.

33. The free-space optical data transmission system of claim 32 wherein the beacon varies in intensity over time.

34. The free-space optical data transmission system of claim 32 wherein the beacon is data encoded.

35. A free-space optical data transmission system comprising:

a first and a second imaging system spaced from and aimed at each other, wherein each imaging system comprises the adaptive optics imaging system of claim 1;

a first light transmitter operably coupled to the first imaging system for providing first data-encoded light to the first imaging system, that directs the first data-encoded light to the second imaging system;

a second light transmitter operably coupled to the second imaging system for providing second data-encoded light to the second imaging system, that directs the second data-encoded light to the first imaging system;

wherein, for each imaging system, the target object comprises the data-encoded light from the other imaging system and further comprises a beacon in the second wavelength band, wherein a position of the beacon relative to the data-encoded light is known.